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Sag-Tension Analysis of AAAC Overhead Transmission lines for Hilly Areas

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Abstract—**Power system is the transfer of electricity from generation to the point of user location. Power system is composed of generation of power, its transmission and distribution. Transmission system is the main part out of these three in which mostly losses occur. The unchanging factors of the transmission line on which these losses depend are inductance, resistance and capacitance. These constants or unchanging factors play a vital role in the performance of transmission line. For example the capacitance effect will be more and its performance will be affected if the height of transmission line is less from the ground. On the other hand its capacitance will be less but tension will be high if the height of the transmission is high. For this reason a transmission line is connected in a curved or catenary shape known as sag. To minimize tension sag is provided in a transmission line. Sag and tension must be adjusted in safe limits. This immediate paper gives a simulation structure to calculate sag and tension of AAAC (All Aluminum Alloy Conductors of overhead transmission lines with same span length for minimum operating temperature. Three different cases are presented with different towers height and are explained in detail for unequal level span. The results show that the tension and sag increased with height. So great the height difference, higher tensions upon higher towers.**

This paper will be very helpful to find the sag-tension values of AAAC conductor for Unequal level supports without calculating it mathematically.

Keywords-component;sag;tension;transmission system

I. INTRODUCTION

System transferring electricity from generation to transmission is known as transmission system. In transmission system transmission lines and substations play a major role. In power system network the biggest part is incorporated by the lines transporting electricity. Designing and erecting transmission system require proper construction or modeling of these lines.

A transmission systems successive execution depends on kind of transmission model used in the system. Catenary is the term given to the curve shape in which transmission lines are connected between supportive towers or power. Transmission line is never connected in straight line. To minimize the tension in the transmission system sag is provided to the transmission line. Similarly, if the tension is high in transmission line, sag will be minimum and there is a possibility that the conductor may break.

Sag and tension are inversely proportional to each other. However, if sag increase the size of conductor used also increases and the cost is raised. The distance between two towers depends on the sag intensity. If the distance between two towers is significant the sag will also be large.

Sag-Tension computations are aimed at fixing suitable restrictions between sag and tension in order to continue or steady uninterrupted power supply to the users.

With Sag-Tension calculations we can determine the conductor temperature as well as ice and wind; load concurrently. Tension is the limit of towers and conductor to keep the tension limited.

Sag clearance distance is dependent on line crossings and ground. If the clearance distance is less than crossing distance chances are that line faults may occur.

The “V” or “I” configuration also play important role for calculating sag-tension along with quantity of insulator strings.

Naturally, insulator string possesses the attributes of an element. Being element provides add up of great distance to sag created by the conductor.

Considering bunch of conductors is also important in different cases. For each phase two or more conductors are used. Extra high voltage system may use two bunches of conductors per phase. Occasionally, a substation that is accumulating power from generating station may use three conductors or power lines for each phase. Hence, the foundations regarding the sag-tension approximation process are obligatory to examine and guarantee or certify that the result match the true state.

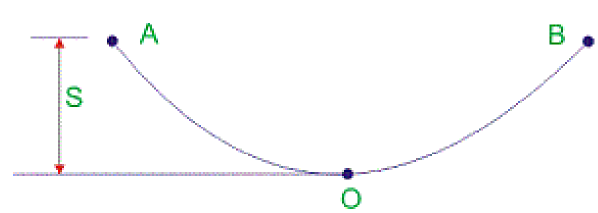

Figure 1. Sag in Overhead Conductor

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The above figure is showing that there are two equal supports named as point A and B. while point O is the lowest point between two supports. Similarly "S" is referred as sag which is distance between the point of support and lowest point of conductor.

II. CALCULATION OF SAG

In overhead transmission line designing, it is important to keep sag under safe limit, and at same time tension running in the conductor is also within safe limit. . As a matter of fact, tension is administered by weight of conductor, ice load on wires, temperature variation and effect of wind. According to common practice, the tension of conductor is kept under 50% of its ultimate tensile power. It means least factor of safety of a conductor tension needs to be two. Now sag as well as tension calculation of a conductor for Unequal support will be carry out [8].

A. *When supports are at Un- equal levels*

In hilly areas, we generally come across conductors Suspended between supports at unequal levels. Figure 2. shows a conductor suspended between two supports A and B Which are at different levels. The lowest point on the conductor is O.

Let

l = Span length

h = Difference in levels between two supports

X_1 = Distance of support at lower level (i.e. A) from O

X_2 = Distance of support at higher level (i.e. B) from O

T = Tension in the conductor

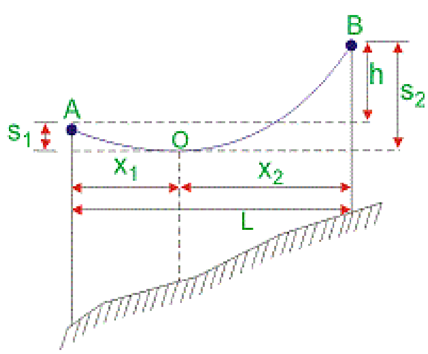

Figure 2. When supports are at Unequal levels

If w is the weight per unit length of the conductor, then

$$Sag\ S_1 = \frac{wx_1^2}{2T}$$

and

$$Sag\ S_2 = \frac{wx_2^2}{2T}$$

Also

$$x_1 + x_2 = l \qquad (\boldsymbol{i})$$

Now

$$S_2 - S_1 = \frac{w}{2T}(x_2^2 - x_1^2) = \frac{w}{2T}(x_2 + x_1)(x_2 - x_1)$$

$$S_2 - S_1 = \frac{wl}{2T}(x_2 - x_1)$$

But

$$S_2 - S_1 = h$$

$$h = \frac{wl}{2T}(x_2 - x_1)$$

$$x_2 - x_1 = \frac{2Th}{wl} \qquad (\boldsymbol{ii})$$

Solving eq. (i) and (ii), we get

$$x_1 = \frac{l}{2} - \frac{Th}{wl}$$

$$x_2 = \frac{l}{2} + \frac{Th}{wl}$$

III. METHODOLOGY

For the result-oriented sag-tension of AAAC transmission line considering different unequal span heights of minimum operating condition are analyze in this research paper.

The tool used for the calculation is ETAP.The module ETAP containing an analytical strength for Transmission and Distribution Line Sag and Tension calculation. It is easily available low cost simulation software to calculate the appropriate sag & tension in order to ensure appropriate operating conditions on the overhead transmission lines.
The spans length for all cases is same which are 200m and the conductors configuration is set as horizontal.
Three Different cases i.e. 1, 2 & 3 are considered.

- In case 1 calculated sag-tension of AAAC overhead transmission lines under minimum operating condition with the height difference of 10m.
- In case 2 calculated sag-tension of AAAC overhead transmission lines with same temperature as previous one but the height difference is 30m.
- In case 3 calculated sag-tension of AAAC overhead transmission lines under minimum operating condition with maximum height difference of 50m.

These calculations are for unequal level spans only and when both the towers are at height difference of 10m, 30m and 50m respectively.

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The conductor used in this paper is AAAC (All Aluminum Alloy Conductor) because:
These conductors are of high strength made of Aluminum-Magnesium-Silicon alloy and are having better ratio of strength to weight enabling the conductors to exhibit more efficient electrical characteristic. They have excellent sag-tension characteristics and superior corrosion resistance when compared with other conductors.
Comparing with traditional ACSR, AAAC are lighter in weight, are having lower electrical losses and comparable strength and current carrying capacity.

IV. Results and Discussion

A. Case 1

In the 1st case, sag-tension under minimum operating temperature i.e. 5˚C with a height difference of 10m is analyzed. As in hilly areas towers are at different heights so in this case we have considered only 10m height difference.

TABLE I. Minimum Temperature with 10m height difference

Type of Conductor	Minimum Temperature (5 °C) and height (10m)			
	Tension		Sag	
	Low Tower	High Tower	Low Tower	High Tower
AAAC	1697	1707	0	10

In the above table sag and tension results of minimum operating temperature with 10m height difference is shown. As it shows above that when support are at 10m height difference the tension on high tower is 1707 while on low tower it is 1697. Similarly incase of sag high tower has more sag 10m than the lower tower. The results are also shown below with the help of graph.

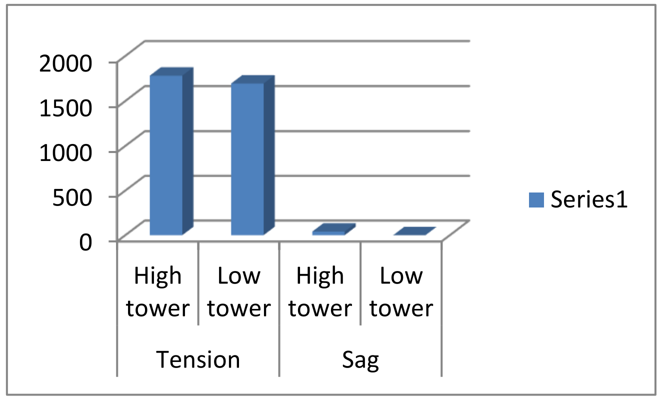

Figure 3. Sag-Tension Results with 10m height difference

B. Case 2

In this case temperature is same as the previous one but the height difference is 30m. As mentioned earlier that hilly areas have different heights for supporting towers so therefore in this case we have consider 30m height difference.

TABLE II. Minimum Temperature with 30m height difference

Type of Conductor	Minimum Temperature (5°C) and height (30m)			
	Tension		Sag	
	Low Tower	High Tower	Low Tower	High Tower
AAAC	1711	1738	0	30

As from the above table sag and tension results of minimum operating temperature with 30m height difference are given. When supports are at 30m height difference the tension on high tower is 1738 while on low tower is 1711. Similarly incase of sag high tower has more sag 30m than the lower tower because high tower exerts high tension. The results are also shown below with the help of graph.

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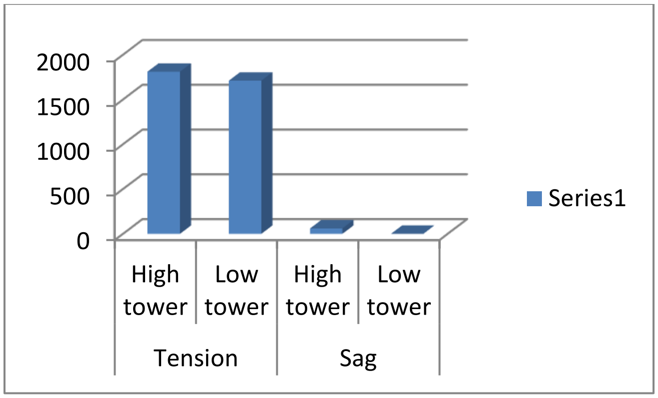

Figure 4. Sag-Tension Results with 30m height differnce

C. Case 3

In 3rd case, sag and tension with minimum operating temperature and height difference of 50m is consider.

TABLE III. MINIMUM TEMPERATURE WITH 50M HEIGHT DIFFERENCE

Type of Conductor	**Minimum Temperature (5 °C) and height (50m)**			
	Tension		**Sag**	
	Low Tower	High Tower	Low Tower	High Tower
AAAC	1747	1793	0	50

In the above table sag and tension results of minimum operating temperature with 50m height difference is mention. The above table shows that when support are at 50m height difference the tension on high tower is 1793 while on low tower is 1747. Similarly incase of sag high tower has more sag 50m than the lower tower. The results are also shown below with the help of graph.

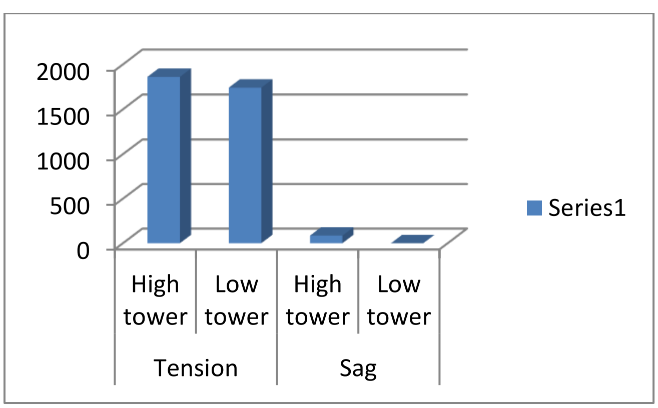

Figure 5. Sag-Tension Results with 50m height differnce

V. CONCLUSION AND FUTURE WORK

This research paper has three different cases which are taken from analysis of sag and tension estimation for AAAC Overhead transmission lines. Equal span length is considered for all cases. Three different towers height were considered with minimum operating conditions. From the results following conclusion is drawn:

In 1st case the temperature is minimum but the height difference was 10m. So when the height difference was minimum (10m) the tension in higher tower is high than the lower tower.

Similarly for 2nd case, the temperature was set same as the previous case but the height difference increased from 10m to 30m. As the height increases the tension will act more force on higher tower as compare to low tower.

In the 3rd case temperature was same again but the height difference was maximum (50m). So due to high difference in towers height the tension on higher tower is also greater due to height. In AAAC the tension and sag increased with height. So great the height difference, higher tensions upon higher towers.

From this paper, one can easily find the sag-tension values of AAAC conductor for Unequal level supports without calculating it mathematically.

In future, the sag-tension estimation of other conductors will also be considered in ETAP.

REFERENCES

[1] I. Albizu, A. J. Mazon, and E. Fernandez (2011). “A method for the Sag-tension, calculation in electrical overhead lines. International Review of Electrical Engineering, volume 6, No. 3 pp. 1380-1389

[2] J. Quintana, V. Garza, C. Zamudio(2016). Sag-Tension Calculation Program for Power Substations. IEEE PES Asia-Pacific Power and Energy Conference- Xi’an-China.

[3] Maamar Taleb, Mohamed Jassim Ditto, Tahar Bouthiba (2006). Performance of Short Transmission Lines Model . University of Bahrain Department of Electrical and Electronics Engineering.

[4] Oluwajobi F. I., Ale O. S. and Ariyanninuola A (2012). Effect of Sag on Transmission Line. Journal of Emerging Trends in Engineering and Applied Sciences (JETEAS) 3 (4): 627-630 © Scholar link Research Institute Journals, (ISSN: 2141-7016).

[5] R.G. Olsen, K.S Edward (2002) “A New method for Real Time Monitoring of High Voltage Transmission line Conductor sag. IEEE Transactions on Power Delivery Vol. 17, No. 4, pp 1142-1152.

[6] Sag-Tension Calculation Methods for Overhead Lines (2007). CIGRE B2-12 Brochure (Ref. No. 324) pp. 31-43.

[7] Seppa T O, 1992, A Practical Approach For Increasing the Thermal Capabilities of Transmission lines, IEEE/PES Summer Meeting, pp 1536-1542

[8] S. Kamboj R. Dahiya (2014) Case Study to Estimate Sag in Overhead Conductors Using GPS to Observe the Effect of Span Length. 978-1-4799-3656-4/14/$31.00 2014 IEEE

[9] V.K. Mehta and Rohit Mehta (2014). Principles Power System. S. Chand and Company Pvt. Ltd. Ram Nagar New Delhi.